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6B

A STUDY OF CITRUS SCAB.

SOME CHEMICAL DIFFERENCES IN LEAF TISSUE WITH REFERENCE TO SUSCEPTIBILITY TO SCAB.

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A BRIEF HISTORY. - Citrus scab is said to have been brought to Florida on Satsuma orange trees introduced from Japan in 1885, and it was presumably brought to Puerto Rico from Florida on nursery trees. It was common, in Puerto Rico, on sour orange and rough lemon in 1904, but the writer did not notice it on grapefruit until 1906. After that it spread fast and in 1911-1912 it attacked the grapefruit crop very severely. Its spread in Florida was comparatively as fast as it was in Puerto Rico. At first it attacked chiefly the lemon, sour and bitter oranges, but later the grapefruit was attacked and still later the sweet orange was found to be not entirely immune. In the dry districts, in the Western States, citrus scab was noticed years ago but it has not become of serious importance. This is attributed to the dry climate, but in Trinidad, British West Indies, where the climate is similar to that of Puerto Rico, scab has been present for many years, yet it does not attack the grapefruit crop there.

SUSCEPTIBILITY. - Scab attacks some species of citrus more than others, and some varieties within the species are susceptible whereas others are practically or entirely immune. This was early observed in Florida, where much material was available for study, and in June 1925 an article was published in the Journal of Agricultural Research of the United States Department of Agriculture, by Winston, Bowman, and Bach in which the relative susceptibility of citrus to scab was tabulated. An extract of that tabulation is presented herewith for the data are applicable to Puerto Rico.

RELATIVE SUSCEPTIBILITY OF SOME RUTACEOUS PLANTS TO CITRUS SCAB.

Botanical name	Common or variety name	Range of susceptibility				
		No infection observed	Very rarely attacked	Slightly susceptible	Moderately susceptible	Very susceptible
Fortunella margarita	Nagami kumquat (oval)		x			
Do. japonica	Marumi kumquat (rd.)	x				
Do crassifolia	Meiwa kumquat	x				
Citrus ichangensis	————	x				
C. medica Linn	Corsican citron	x				
Do	Etrog citron	x				
C. limonia Osbeck	Dwarf Chinese lemon				x	
Do	Kenedy lemon					x
Do	Lamb lemon					x
Do	Rough lemon					x
Do	Sweet lemon				x	
Do	Villa Franca lemon					x
C. janos Tan	Kansu orange	x				
C. aurantifolia	Kusaie lime					x
Do	Mexican lime	x				
Do	Persian lime	x				
Do	Sour Rangpur lime					x

RELATIVE SUSCEPTIBILITY OF SOME RUTACEOUS PLANTS TO CITRUS SCAB. (Contd.)

Botanical name	Common or variety name	Range of susceptibility				
		No infection observed	Very rarely attacked	Slightly susceptible	Moderately susceptible	Very susceptible
C. aurantifolia	Tahiti lime			x		
Do	Thornless lime	x				
Do	Woglum lime	x				
C. grandis Osbeck	Conner grapefruit				x	
Do	Davis grapefruit				x	
Do	Duncan grapefruit				x	
Do	Foster grapefruit				x	
Do	Gold Medal grapefruit				x	
Do	Hall (Silver Cluster) grapefruit				x [a] x	
Do	Leonardi grapefruit				x	
Do	Marsh grapefruit				[b] x	
Do	Pink Marsh grapefruit				x	
Do	McCarty grapefruit				x	
Do	Pernambuco grapefruit				x	
Do	Royal grapefruit	x				
Do	Triumph grapefruit	x				
Do	Walters grapefruit				x	
Do	Chinese pummelo				x	
Do	Pink pummelo				x	
Do	Sour pummelo				x	
Do	Common shaddock				x	
Do. (?)	Cuban shaddock	x				
C. aurantium Linn	Bergamot orange	x				
Do	Bitter sweet orange					x
Do	Willow leaf bitter sweet orange				x	
Do	Myrtle leaf orange				x	
Do	Otaheite orange	x				
Do	Sour orange					x
C. sinensis Osbeck	Chamoudi orange	x				
Do	Florida Seedling orange		x			
Do	Enterprise orange	x				
Do	Homosassa orange	x				
Do	Jaffa orange	x				
Do	Lamb orange	x				
Do	Lue orange		x			
Do	Maltese orange		x			
Do	Mediterranean sweet orange		x			
Do	Norris early orange	x				
Do	Parson Brown orange	x				
Do	Pineapple orange		x			
Do	Ruby orange	x				
Do	Surprise orange	x				
Do	Valencia orange	x				
Do	Washington navel orange		x			
C. nobilis Lour	King orange					x
C. nobilis deliciosa	Clementine orange				x	
Do	Cleopatra Mandarin	x				
Do	Dancy tangerine				x	
Do	Oneco tangerine				x	
Do	Mandarin				x	
C. nobilis unshiu	Satsuma				x	
C. mitis Blanco	Calamondin					x

[a] More susceptible than most commercial varieties.
[b] Less susceptible than most commercial varieties.

One of the interesting facts about citrus scab is the practical immunity of some, such as kumquats and citron, most of the limes and all the round sweet oranges, whereas others such as sour and bitter sweet oranges are very susceptible

and lemons usually are so. The grapefruits are susceptible but less so than the former group, and the Royal and Triumph varieties as well as the Cuban shaddock are immune. The kid-glove oranges are usually susceptible, but in that group the Cleopatra Mandarin forms an exception.

PROBLEMS INVOLVED. - It is natural to ask: (1) Why those differences? (2) If chemical, are they due to substances that are known to be present in citrus? (3) If not, what other probable substances may be expected to be factors? (4) Considering that only young growth of foliage and fruit is attacked, what are the differences between such growth and that which is more mature? These questions the writer is endeavoring to answer and this article is a report upon the work now in progress.

MOISTURE CONTENT. - Other conditions being equal the foliage and fruit of any one tree is usually susceptible to scab according to the vegetative vigor and the state of maturity of the tissue. An abnormally vigorous foliage containing 75% or more of moisture is much more susceptible to scab than that containing less than 70%; perhaps in most cases the tissue containing less than 65% is resistant. The normal old mature leaves usually contain about 60% moisture.

PLASTID PIGMENTS. - The pigments chlorophyll, xanthophyll, and carotin are found in greater quantities in old than in young tissue; usually the ratio is three to one or more according to maturity. No differences were observed between susceptible and immune trees that would indicate that pigments are factors in susceptibility to scab.

O I L . - The oil content of the tissue generally increases with maturity. The increase is not, however, as large nor as invariable as in the case of pigments. The variation in oil content between species and varieties is not such as to indicate that it is a factor in susceptibility to scab. But the variation in composition of the oil seems to be a factor. It may be casual, of course, but the fact is that young growth contains more aldehyde than old growth on the same tree. Also the leaf tissue of rough lemon, sour orange and most grapefruit contains more aldehyde than that of sweet orange and citron. The significance of that, if any, will be reported upon later.

W A X . - Citrus leaves are covered with a layer of wax which varies in thickness with the maturity of the tissue. The amount extracted from the young tender leaves was found to be but one-fourth to one-half of that secured from old mature leaves. The amount of wax extracted from leaves of trees that are susceptible to scab did not vary regularly from that extracted from leaves of immune trees. On the other hand some variation in the nature or composition of the wax was noted. The significance of that, if any, will be reported upon later.

A C I D S . - The acid content of leaf tissue is not constant. While the young growth usually contains more acid than the mature, the reverse is sometimes the case. In regard to species and varieties it is not unusual to find rough lemon and sour orange of which the sap shows a higher pH and a greater amount of titrable acid than that of sweet orange, but that condition is not constant. It would seem, therefore, that the acidity of the tissue is not a factor in susceptibility to scab.

SOLUBLE CARBOHYDRATES. - The results of previous investigations reported in the annual report of this Station for 1930 showed that the content of soluble sugars is usually twice or three times greater in young than in old growth. That seems to be the case regardless of species or variety, but no differences were noted that would seem to be germane to the question - why some are susceptible and others immune to scab.

GLUCOSIDES. - The content of glucosides was found to be in all cases greater in young, partly mature, than in old, fully matured, leaves. But the variation in content when applied to species and varieties was not found to parallel lines of susceptibility to scab. The difference in composition of the glucosides may be a factor. That will be further investigated and reported upon later.

SOLUBLE PROTEIN. - No attempt was made to segregate the various protein fractions beyond that which is soluble in cold water. That fraction was found to be more abundant in the young than in the old tissue. Further investigation may show some protein fraction to be a factor in susceptibility to scab, but from present indications it seems doubtful.

SPECIFIC NITROGEN PRODUCTS. - Indole has been reported to be present in citrus tissue. In this investigation it was found to be present in both young and old leaf tissue of all the species and varieties examined. But the variation in content was not found to parallel susceptibility to scab.

Stachydrine is another product that has been found in citrus by several investigators. But since it has been found in species as widely different as the orange and the lemon it seems improbable that it is a factor in susceptibility to scab.

C O N C L U S I O N S. - It is readily apparent to the eye that the old mature tissue which is resistant to scab is much firmer in texture than the young tissue which is subject to scab. The cause for that difference is explainable by the results of this investigation. The content of moisture, soluble carbohydrates and soluble proteins is greatest in the young tissue, whereas the content of pigments and oil is greatest in the old tissue. Any one of these factors or all of them together may be the cause of difference in tissue texture. And the firmness of the mature tissue together with the greater wax content may readily be the reason why it is resistant to scab. Whether or not the difference in glucoside content is a factor will have to be proved. The reason why one species or variety is susceptible to scab, whereas another is immune, has yet to be demonstrated. The results of this investigation indicate that further examination of wax, oils, and glucosides may, perhaps, suggest remedial measures for scab control. A report upon that will be submitted later.